DOCUMENT RESUME

ED 366 508 SE 054 135

AUTHOR	Berlin, Donna F.; White, Arthur L.
TITLE	Integration of Science and Mathematics: What Parents Can Do.
INSTITUTION	National Center for Science Teaching and Learning, Columbus, OH.
SPONS AGENCY	Office of Educational Research and Improvement (ED), Washington, DC.
PUB DATE	Sep 93
CONTRACT	R117Q00062
NOTE	22p.; 1993 Digest Article.
AVAILABLE FROM	National Center for Science Teaching and Learning, 1929 Kenny Road, Columbus, OH 43210-1080 ($1).
PUB TYPE	Guides - Non-Classroom Use (055)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Elementary Secondary Education; *Interdisciplinary Approach; Mathematics Education; Parent Influence; *Parent Participation; Parents as Teachers; *Science Activities; Science Education; *Science Instruction
IDENTIFIERS	National Center for Science Teaching and Learning; Science Process Skills

ABSTRACT

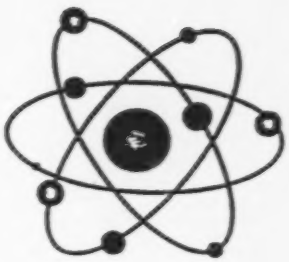
The purpose of this digest is to suggest to parents opportunities and experiences in their daily life that can help to illustrate the integration of science and math. It is hoped that parents will share these and other experiences with their children and the results of these experiences with The National Center for Science Teaching and Learning. This digest, written for parents and their children, provides: (1) a review of national science and mathematics education reform documents, (2) a description of the Berlin-White Integrated Science and Mathematics Model, (3) parents and children at-home activities, and (4) selected resources. (PR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

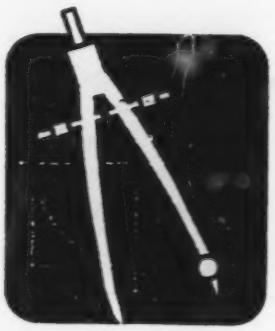
INTEGRATION OF SCIENCE AND MATHEMATICS

WHAT PARENTS CAN DO

ED 366 508



by



Donna F. Berlin
&
Arthur L. White

The National Center for Science Teaching and Learning

1993 Digest Article
September, 1993

SE 054 135

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

BEST COPY AVAILABLE

Writing of this paper was supported by the National Center for Science Teaching and Learning under grant #R117Q00062 from the Office of Educational Research and Improvement, U. S. Department of Education. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the sponsoring agencies.

INTRODUCTION

Purpose

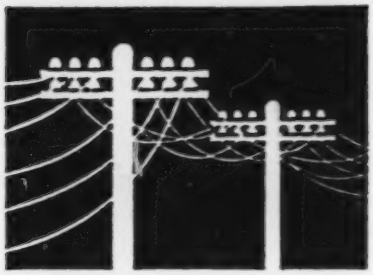
In the presence of your children, how often have you said " Well I never was very good in science [or math]" or "Knowing science [or math] sure helped me today." Our comments can make lasting impressions on our children's attitudes.

How often have your children come home from school and said "Science is boring" or "Math is just too hard"? These and similar comments like "When will I ever use this stuff?" are echoed in classrooms throughout the nation. Science and math related experiences need to be made more personal and relevant to student's immediate and future interests and needs. Often solutions to real world problems depend upon an understanding of both science and math in an integrated way. Examples of some of these problems might include: (a) *What should the shape of a garden plot be so that you have as much space as possible to grow your garden with the least amount of fencing needed to enclose it?* (b) In sports involving balls such as baseball, golf, pool, and tennis; *How does the size, weight, spin, and rebounding surface influence the bounce and curve of the ball?* (c) *How does the octane of the gasoline, the number of people in the car, the speed, and the terrain effect how many miles you can get from a tank of gasoline?* (d) *How does the shape and size of floor tile and the symmetry of the design relate to the laying of bathroom tile?* Parents should help their children to be aware of meaningful, positive examples of this integration that relate to their lives now and in the future.

We all need to understand the way the world around us works. We cannot be compartmentalized by specific subject matter skills or attitudes. If we are to prepare our children for the future we must do a better job of connecting science and math and connecting school science and math to "street" science and math or real life applications.

The educators and researchers at The National Center for Science Teaching and Learning (NCSTL) are seeking the assistance of parents and others in order to identify a broad range of ways in which science and math are connected in the lives of the public at large. We all need to be actively involved in identifying real

world science and math connections. We are asking parents to think about how science and math are connected in their lives - their occupation, leisure time, or recreation - and share these with their children. The goal is to stimulate and support student, parent, and community involvement in science and mathematics education. The more of us who are aware and alert to the science and math connections around us, the greater the public consciousness, and the more unified we can be in improving our children's attitudes, performance, and confidence related to science and math.



The purpose of this digest is to suggest to parents opportunities and experiences in their daily life that can help to illustrate the integration of science and math. It is our hope that parents will share these and other experiences with their children and the results of these experiences with The National Center for Science Teaching and Learning.

This digest, written for parents and their children, provides:

- a review of national science and mathematics education reform documents,
- a description of the Berlin-White Integrated Science and Mathematics (BWISM) Model,
- parent and children at-home activities, and
- selected resources

related to the integration of science and math.

NATIONAL SCIENCE AND MATHEMATICS REFORM DOCUMENTS

The integration of science and mathematics teaching and learning has received much attention in current education reform documents. These documents suggest that this integration may improve student understanding and performance and

develop realistic and positive attitudes related to both science and math. The youth of today need the opportunity to develop a functional level of scientific and mathematical literacy, the motivation to excel in science and math, and the propensity to select science and math related careers. The integration of science and math has the potential to help our young people to perceive the relevance and the power of this union.

> The alliance between science and mathematics has a long history, dating back centuries. Science provides mathematics with interesting problems to investigate, and mathematics provides science with powerful tools to use in analyzing data. (Rutherford & Ahlgren, 1990, pp. 16-17)

> Since mathematics is both the language of science and a science of patterns, the special links between mathematics and science are far more than just those between theory and applications. The methodology of mathematical inquiry shares with the scientific method a focus on exploration, investigation, conjecture, evidence, and reasoning. Firmer school ties between science and mathematics should especially help student's grasp of both fields (National Research Council, 1990, pp. 44-45).

Clearly, current science and mathematics education reform documents support the idea of integrated science and mathematics education.

In 1991, a group of 60 individuals representing scientists; mathematicians; science and mathematics educators; elementary, middle, and senior high school teachers; curriculum developers; educational technologists; and psychologists assembled at a federally-funded conference to explore the integration of science and mathematics education. A number of benefits related to the integration of school science and math were identified:

- improve understanding by connecting ideas;
- improve efficiency by teaching science and math together;
- capture students' natural curiosity;

- develop a persistent and infectious excitement for making sense of things;
- encourage children to make guesses, gather evidence, develop arguments to support their reasoning, construct models, and explore their implications;
- build an appreciation for problem solving - recognizing that problems are not solved quickly and do not always lead to one right solution;
- encourage decision making - selecting different strategies and outcomes among multiple solutions;
- increase motivation through activities relevant to present student needs and future work needs;
- develop confidence in their abilities to do both science and math;
- expose and encourage students to think about science and math-related careers
- increase opportunity for out-of-school experiences and resource persons to become involved; and
- remove the artificial boundaries so that children will learn to look at science and math together in school with a more holistic view as they naturally do outside of school.

What eluded the conference participants, however, was how to define the integration of science and mathematics education. To address this issue, the Berlin-White Integrated Science and Mathematics (BWISM) Model was developed.

BERLIN-WHITE INTEGRATED SCIENCE AND MATHEMATICS (BWISM) MODEL

The integration of science and math cannot be simply defined. The

definition involves a broad range of aspects. The Berlin-White Integrated Science and Mathematics (BWISM) Model identifies six aspects: (a) **ways of learning,** (b) **ways of knowing,** (c) **process and thinking skills,** (d) **content knowledge,** (e) **attitudes and perceptions,** and (f) **teaching strategies.**

We do not intend to imply that these aspects are isolated nor exclusive of one another in reality. It is expected that the real value of this exercise will be in identifying the "connections" among these aspects within and across science and math rather than attending to them in isolation.

Ways of Learning. Integration can be based on how students experience, organize, and think about science and math. To learn science and math effectively, students must do science and math. They must be involved in an active learning process. Learning takes time and grows best from familiar surroundings. A child's base of experience serves as the foundation for understanding "big ideas". It is important that children have the opportunity to share the understanding of these "big ideas" with you and others.

Ways of Knowing. From the day they are born, children are curiously looking for patterns to help them make sense of their world. These patterns help them to know what to do in new and strange situations. They often have to take their "best guess" in order to make decisions in new situations. Sometimes the guess will work out and sometimes it won't. When it does, it generally becomes a part of the child's knowledge. When it doesn't the child may revise his/her thinking and try something different. This process guides us all (including scientists and mathematicians) in learning about our world and may be described as inductive and deductive ways of knowing.

Simply put, induction is the process of looking at numerous examples to find a pattern which we then translate into a rule. The application of this rule in a new context is the process of deduction. Integrated science and math activities can provide opportunities to move back and forth between the inductive and deductive ways of knowing.

Process and Thinking Skills. Integration of science and math can be viewed from the ways we collect and use information through investigation, exploration, experimentation, and problem solving. These skills include: classifying, collecting and organizing data, communicating, controlling variables, developing models, estimating, experimenting, graphing, inferring, interpreting data, making hypotheses, measuring, observing, recognizing patterns, and predicting.

Content Knowledge. Integration can be viewed from the perspective of the overlap of science and math content. This requires an examination of the concepts, principles, and theories of science and math so as to determine which ideas are unique to science or to math and which ideas may overlap.
Some of the "big ideas" which are common to both science and math include: balance, conservation, equilibrium, measurement, models (including physical, conceptual, and mathematical), patterns (including trends, cycles, and chaos), probability, reflection, refraction, scale (including size, duration, speed), symmetry, systems, variable, and vectors. There are times when the content of science and the content of math have enough in common so that it would be more meaningful to the student and more efficient to integrate science and mathematics education.

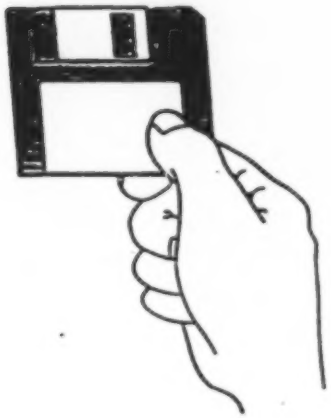
Attitudes and Perceptions. Integration may also be viewed from what children believe about science and math, how they feel about their involvement in science and math experiences, and their confidence in their ability to do science and math.

There are many values, attitudes, and ways of thinking shared between science and mathematics education. They include: accepting the changing nature of science and mathematics, basing decisions and actions on data, a desire for knowledge, a healthy degree of skepticism, honesty and objectivity, relying on logical reasoning, willingness to consider other explanations, and working together to achieve better understanding.

Integrative science and math experiences based upon personal and social issues and interests may motivate students to achieve. These

opportunities may help to encourage, support, and nurture student confidence in their ability to do science and math. These experiences may also help to counter the perception of science and math as difficult, accessible to only a select group of individuals (e.g., white, Anglo males), and not essential to the general public.

Teaching Strategies. The goal of integrated science and mathematics teaching is to enable students to "... acquire both scientific [and mathematical] knowledge of the world and scientific [and mathematical] habits of mind at the same time." (Rutherford & Ahlgren, 1990, p.190) Such an environment would include a broad range of content, provide time for inquiry-based learning, provide opportunities to use laboratory instruments and other tools; provide appropriate and ongoing use of technology such as calculators and computers, and maximize opportunities for successful experiences. We must constantly attend to bridging the gap between school science and math and real world science and math.



PARENT AND CHILDREN AT-HOME ACTIVITIES

Parent Awareness and Involvement

Aspects of science and math exist together in our lives in a variety of ways. It is rare that the average person can go even part of a day without using science and math together in the workplace or during private and leisure time. This common occurrence tends to be taken for granted and very seldom do we take notice. What we need to do is become more alert to these occasions, identify them, and help our young people perceive and experience them.

Providing opportunities for children to recognize integrated science

and math experiences in the real world will help to elevate their perception of the value of science and math to them both now and in the future. This awareness may also motivate them to explore both the qualitative and quantitative characteristics of the world in which they live.

Parents can be alert to when, where, and how science and math together play a part in their lives. Make a list and share that with your children. Just being aware of the role that science and math play in your life will help you to develop a valuing attitude which by example can influence the attitudes and perceptions of your children.

Encourage your children to look for the instances in their daily lives which relate to science and math. The more they are aware and the more that they recognize that science and math, working together, can be important to them the more apt they are to pursue and excel in these areas. Often children ask parents and teachers "Why do I have to take science and/or math? I will never use it." It is important that we give children the exposure and the opportunity to experience their world through the "eyes" of science and math in a way that "connects" them with science and math.

Questions to Think About

As you begin to explore integrated science and math in your life and that of your children, the following questions may serve to stimulate your thinking. These questions are based upon the interrelated aspects of the Berlin-White Integrated Science and Mathematics (BWISM) Model.

- Do your children have the opportunity to explore objects and events by manipulating things to find out what happens?

- Do your children have the opportunity to make guesses about what will happen based on observations and past experiences?

- Do your children have the opportunity to see how good their guesses are?

- Do your children have experiences at home involving collecting things, building or making things, recognizing and extending patterns, measuring, estimating, drawing, or designing?

- Do your children have the opportunity to use science and math knowledge in playing games?

- Do your children have the opportunity to talk with you and others about things and events which involve ideas of science and math?

- Are your children aware of how science and/or math are a part of your job and/or your personal life?

- Are you aware of the national, state, and local science and mathematics curriculum standards?

- Are you aware of the science and mathematics curriculum, instructional resources, facilities, and scheduling in your children's school and how these align with national, state, and local standards?

Things You Can Do

- Keep a record of your uses of both science and math (together) for a day each week (e.g., 1st week - Monday, 2nd week - Tuesday, 3rd week - Wednesday, 4th week - Thursday, 5th week - Friday, 6th week - Saturday, and 7th week - Sunday. Share with your children the ways you use science and math.

- Review newspapers, magazines, and television programs to identify reporting involving science and math.

- Look for books of activities, stories, cartoons, ... which portray "good" science and math.

- Make a collection of "good" activities which integrate science and math.

- Have children make graphs AND interpret them.

- Look for toys which involve science and/or math to make or buy for your children.

- Discuss with your children the importance of connections between science and math.

- Instill in your children the self-confidence needed for them to learn science and math.

- Encourage your children to study science and math every year in their school career.

- Be knowledgeable about the science and mathematics curriculum in your children's schools.

- Be knowledgeable about the national, state, and local science and mathematics standards.

- Help to ensure that school budgets are adequate for meeting the national, state, and local science and mathematics standards.

Sharing Perspectives

The educators and researchers at The National Center for Science Teaching and Learning would appreciate the opportunity to benefit from your perspective and experiences. If you would send us descriptions and reactions related to your integrated science and math experiences with your children, we can use them to better

connect out-of-school experiences to school-based learning experiences.

A list of examples of how the connections between science and math influence you in your occupation, leisure time, and/or recreational activities would be most useful. We are looking to parents to provide ideas for integrated science and math classroom activities that would mirror real world experiences.

Please send all information to:

Donna Berlin or Arthur White
NCSTL
1929 Kenny Road
Columbus, OH 43210-1081

SELECTED RESOURCES

Selected Resources Related to Science and Mathematics Education Curriculum Reform:

These publications provide a concise view of current science and mathematics education reform highlights and recommendations.

1. American Association for the Advancement of Science. (1989). Science for All Americans. Executive Summary. Washington, DC: Author.

   Available for $10.95* from:
   American Association for the Advancement of Science
   1333 H Street NW, Washington, DC 20005
   (202) 326-6400 Fax (202) 842-5196

2. Berlin, D. F., & White, A. L. (1992, October). Report from the NSF/SSMA Wingspread Conference: A Network for Integrated Science and Mathematics Teaching and Learning. School Science and Mathematics, 92(6), 340-342.

   Available free from:
   The National Center for Science Teaching and Learning
   1929 Kenny Road
   Columbus, OH 43210-1081
   (614) 292-3339 Fax (614) 292-1595

3. National Council of Teachers of Mathematics. (1989). Curriculum and Evaluation Standards for School Mathematics. Executive Summary. Reston, VA: Author.

   Available for $1.50 (minimum order is 10 copies) from:
   National Council of Teachers of Mathematics
   1906 Association Drive
   Reston, VA 22091
   (800) 235-7566 (toll free) (703) 620-9840 (VA) Fax (703) 476-2970

4. National Research Council. (1989). Everybody Counts. A Report to the Nation on the Future of Mathematics Education. Summary. Washington, D. C.: National Academy Press.

Available for $2.95 from:
National Academy Press
2101 Constitution Avenue, NW
Box 285
Washington, DC 20055
1-800-624-6242 (toll free) 334-3313 (DC)

5. National Research Council. (1990). Reshaping School Mathematics: A Philosophy and Framework for Curriculum. Washington, DC: National Academy Press.

Available for $7.95 from:
National Academy Press
2101 Constitution Avenue, NW
Box 285
Washington, DC 20055
1-800-624-6242 (toll free) 334-3313 (DC)

6. National Research Council. (1993, February). National Science Standards. An Enhanced Sampler. Washington, DC: Author.

Available free from:
National Research Council
2101 Constitution Avenue, NW
HA 487
Washington, DC 20418
(202) 334-1399 Fax (202) 334-3159

7. National Research Council. (1993, July). National Science Standards. July'93 Progress Report. Washington, DC: Author.

Available free from:
National Research Council
2101 Constitution Avenue, NW

HA 487
Washington, DC 20418
(202) 334-1399 Fax (202) 334-3159

Selected Resources Related to Integrated Science and Math Activities: Current

Although these materials have been designed for use by classroom teachers, they are also appropriate for use by parents as the procedures and needed materials are clearly presented and the activities do not require an extensive background in either science or math.

1. The AIMS Education Foundation publishes a series of integrated science and math activity books that are priced from $10.95 to $14.95[b] (1993 prices). Many of the books are also published in Spanish. The activities are designed for students in kindergarten through grade 9 and each book contains activities related to a specific theme. Some of the titles include: Critters; Electrical Connections; Floaters and Sinkers; Fun with Foods; Glide into Winter with Math and Science; Math + Science, A Solution; Mostly Magnets; Our Wonderful World; Soap Films and Bubbles; and Water Precious Water.

   A catalogue of the AIMS Programs and Products along with purchasing information is available from the:
   AIMS Education Foundation
   Activities that Integrate Math and Science (AIMS)
   P. O. Box 8120
   Fresno, CA 93747-8120
   (209) 255-4094 Fax (209) 255-6396

2. Berlin, D. F. (1991). Integrating Science and Mathematics in Teaching and Learning: A Bibliography. Columbus, OH: ERIC Clearinghouse for Science, Mathematics and Environmental Education.

This bibliography includes a section listing 251 integrated science and math activities that can be found in various science and mathematics education journals. Complete bibliographic information is provided.

A copy of the reference list of integrated science and math activities can be obtained free by writing to:
The National Center for Science Teaching and Learning
1929 Kenny Road
Columbus, OH 43210-1081
(614) 292-3339 Fax (614) 292-1595

3. Berlin, D. F. (Ed.). (1992). SSMILES: School Science and Mathematics Integrated Lessons. Columbus, OH: The National Center for Science Teaching and Learning.

This document is a compilation of the SSMILES: School Science and Mathematics Integrated Lessons that have appeared in the School Science and Mathematics journal since April, 1987. The integrated science and math activities are appropriate for students in grades pre-kindergarten through college. The authors identify the science and math concepts, skills, and processes; prerequisite skills, objectives, content background, materials/supplies, procedures, extensions, and references.

This publication can be obtained for $7.50[c] from:
The National Center for Science Teaching and Learning
1929 Kenny Road
Columbus, OH 43210-1081
(614) 292-3339 Fax (614) 292-1595

4. Farmer, W. A., & Farrell, M. A. (1989, Spring). Activities for Teaching K-6 Math/Science Concepts. (School Science and Mathematics Association Classroom Activities Series Number 2). Bowling Green, OH: School Science and Mathematics Association.

This book contains 10 integrated science and math activities for children in grades kindergarten through 3 and 10 integrated science and math activities for children in grades 4 through 6. Each activity involves important math and science learnings in a single lesson, has been tried out by classroom teachers and elementary school children, involves hands-on activity and uses readily available, everyday materials. The authors identify the Procedures, Materials, Key Concepts, Skills and Processes, and Useable Junk for the activities.

This book can be obtained for $7.50[d] by writing to:
School Science and Mathematics Association
Bowling Green State University
126 Life Science Building
Bowling Green, OH 43403-0256
(419) 373-7393 Fax (419) 372-2327

5. Great Explorations in Math and Science (GEMS) is a series of activity books integrating math with life, earth, and physical science published for students in grades pre-school through high school. Titles include: Discovering Density, Global Warming & the Greenhouse Effect, Hot Water and Warm Homes from Sunlight, Liquid Explorations, More Than Magnifiers, Paper Towel Testing, and Vitamin C Testing. Prices range from $7.50 to $15.00[e].
A catalogue of the GEMS materials along with purchasing information is available from the:

Lawrence Hall of Science
University of California
Berkeley, CA 94720
(510) 642-7771 Fax (510) 642-1055

6. House, P. A. (1980). Interactions of Science and Mathematics. (School Science and Mathematics Association Topics for Teachers Series Number 2). Bowling Green, OH: School Science and Mathematics Association.

This publication provides integrated science and math activities appropriate for students in junior and senior high schools. Topics include functions (e.g., springs, thermometers, and speed vs time); measurement (e.g., human reaction time, earthquakes, and parallax); ratio and proportion (e.g., measuring heights, gears, and human proportions); spatial requirements (e.g., reflections, lenses, and stereograms); and modeling, predicting, and decision making (e.g., balance beams, electrical circuits, and populations).

This book can be obtained for $7.50[d] by writing to:
School Science and Mathematics Association
Bowling Green State University
126 Life Science Building
Bowling Green, OH 43403-0256
(419) 373-7393 Fax (419) 372-2327

[a] Shipping and handling $1.50

[b] Shipping/handling @ 10%
California Residents Pay Sales Tax

[c] All orders must be prepaid (check or money order)

[d] Postage included on prepaid orders.

[e] Shipping charges vary according to number of books ordered.
California Residents Pay Sales Tax

Selected Resources Related to Integrated Science and Math Activities: On the Horizon

1. Berlin, D. F. (Ed.) Database of Integrated Science and Mathematics Instructional Activities. Columbus, OH: The National Center for Science Teaching and Learning.

This database of integrated science and math activities appropriate for students in grades kindergarten through 12 will be available on computer disk and in print form. The database will include complete bibliographic information as well as fields identifying grade level; science and math concepts, skills, and processes; a brief description of the activity; time requirements; materials; and comments.

2. White, A. L., & Berlin, D. F. (Ed.) Exemplary and Cutting-Edge Integrated Science and Mathematics Instructional Materials. Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.

This database will include integrated science and math curriculum materials available in print, video, audio, software, other graphics, and CD-ROM. The materials are appropriate for students in grades kindergarten through 12. This database will be available in print in a mini-catalog, on CD-ROM, or online through electronic access (e.g., Internet).

NOTES

The following notes refer to the text portion of this digest.

Page 5. Examples of the national science and mathematics education reform documents include:

American Association for the Advancement of Science. (1989). Project 2061. Science for All Americans. Washington, D.C.: Author.

Mathematical Science Education Board. (1991). Counting on You: Actions Supporting Mathematics Teaching Standards. Washington, DC:, National Academy Press.

National Council of Teachers of Mathematics. (1989). Curriculum and Evaluation Standards for School Mathematics. Reston, VA: Author.

National Research Council. (1989). Everybody Counts. A Report to the Nation on the Future of Mathematics Education. Washington, D. C.: National Academy Press.

National Research Council. (1992, October). National Science Standards. Discussion Document. Washington, DC: Author.

National Research Council. (1993, February). National Science Standards. An Enhanced Sampler. Washington, DC: Author.

National Research Council. (1993, July). National Science Standards. July'93 Progress Report. Washington, DC: Author.

National Research Council. (1990). Reshaping School Mathematics. A Philosophy and Framework for Curriculum. Washington, D. C.: National Academy Press.

Rutherford, E. J., & Ahlgren, A. (1990). Science for All Americans. New York: Oxford University Press, Inc.

Page 8. Rutherford, E. J. & Ahlgren, A. (1990). Science for All Americans. New York: Oxford University Press, Inc., page 190.